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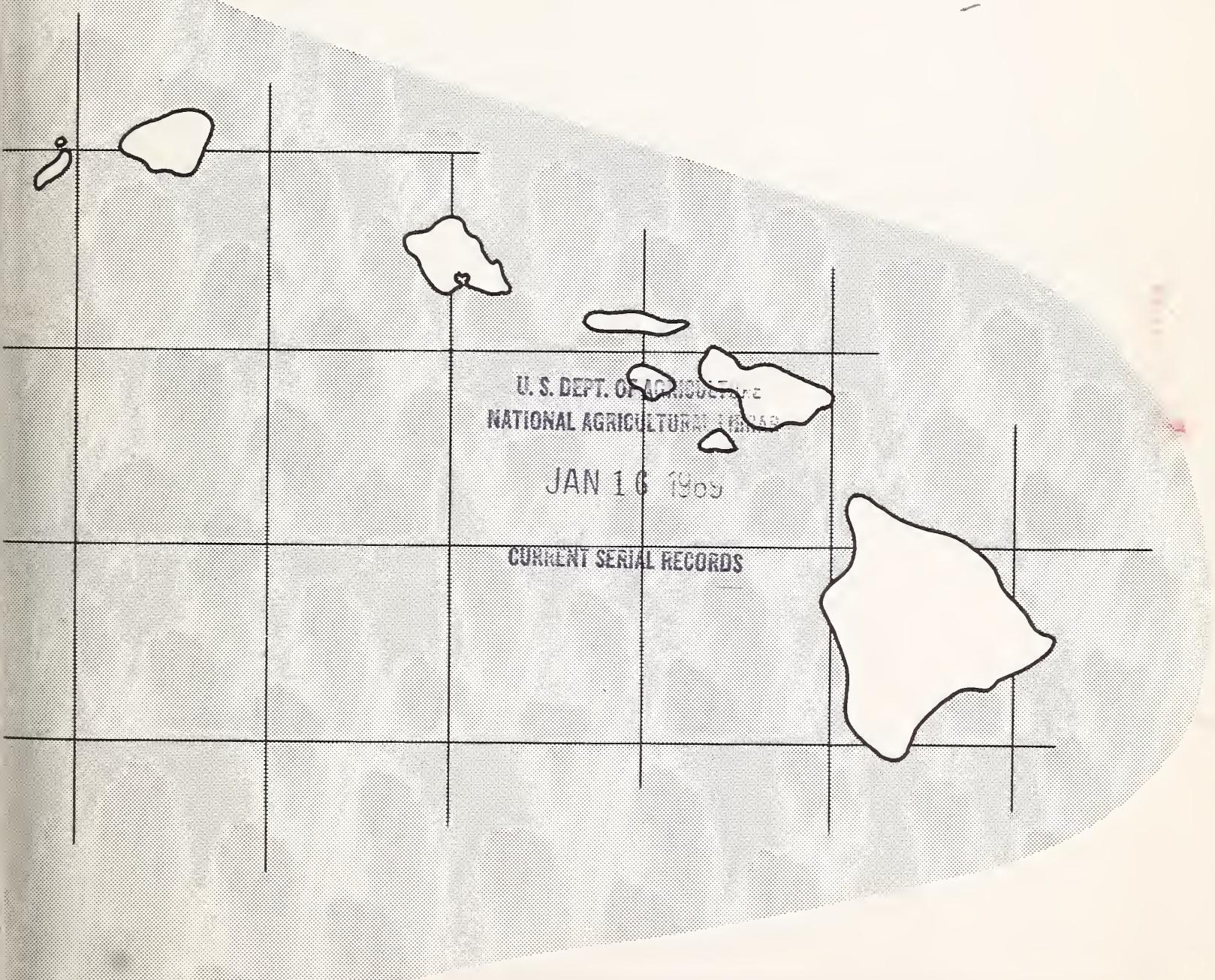


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Records and Maps of

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Honolulu, Hawaii 96813



# Records and Maps of Forest Types in Hawaii

Robert E. Nelson

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#### ACKNOWLEDGMENTS

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**H**ow does forest vegetation in Hawaii differ today from that a thousand years ago? What is the present nature and extent of forests in the Islands? In 1958 the U.S. Forest Service began to survey the forest resources of Hawaii to collect information for land use planning and management. As part of this job we compiled maps of forest types to show vegetation cover. And, in the process of making the forest resource survey, we looked into past as well as present records. The information we have gathered on former vegetation and land use should be useful to geographers, ecologists, historians, and students.

The present pattern of dominant plant associations in Hawaii and their floristic composition has resulted from marked and rapid change. Beginning more than a thousand years ago with the first Polynesian settlers, the impact of agriculture has profoundly changed the vegetation composition and distribution. When Captain James Cook discovered the Islands in 1778, he saw in large part a man-made and managed landscape. Change was accelerated after discovery of the Islands and continues today at a rapid rate. Both forests and other plant communities have been greatly affected.

## Early Records of Vegetation

The record of vegetation in the Islands in the late 1700's is not entirely clear, but we do have accounts by many early visitors who wrote about the landscape they saw. Some writers provided details about one location or another, including descriptions of vegetation types and plants encountered (Hosaka 1931; Korte 1961; MacCaughey 1918). From these descriptions we can visualize the major vegetation features of the landscape. Much of the lowlands, even in wet areas, must have lacked forest, and a large part was probably cultivated.

One of the early visitors, Menzies (1793), wrote about lands in Hamakua:

"The land we passed in the forenoon rose in a steep bank from the waterside and from thence the country stretched

back with an easy acclivity for about four or five miles, and was laid out in little fields, apparently well cultivated and interspersed with habitations of the natives. Beyond this the country became steeply rugged and woody, forming mountains of great elevation."

After sailing from Hamakua and anchoring at Kawaihae, he wrote:

"From the north-west point of the Island, the country stretched back for a considerable distance with a very gradual ascent, and is destitute of trees or bushes of any kind. But it bears every appearance of industrious cultivation by the number of small fields into which it is laid out...."

Menzies wondered how the dry rocky lowlands could support such a large number of people. His statements suggest that the Waimea area of the Island of Hawaii was heavily populated and cultivated as was the area above Kealakekua Bay inland from the lower "dry barren rocky country":

"For several miles around us there was not a spot that would admit of it but what was with great labor and industry cleared of the loose stones and planted with esculent roots or some useful vegetable or other.... But seeing now these upper regions so industriously cultivated and teeming with productive crops, we could no longer remain ignorant of their vast resources...."

Fifteen years earlier, in 1778, David Nelson, the first botanist to visit the Hawaiian archipelago, had landed with Captain Cook on the Kona coast. He and John Ledyard attempted to climb Mauna Loa from Kealakekua. They noted that the forests did not reach the shore. Wrote Ledyard:

"It was now near sunset, and being upon the skirts of these woods, that so remarkably surrounded this island at a uniform distance of four or five miles from the shore, we concluded to halt,... ."(MacCaughey 1918a, pp. 388-396).

The "native" landscape that Captain Cook and other early visitors saw in the lowlands was largely a result of activities for a thousand years of the heavy Hawaiian population. It is common knowledge that the Hawaiians had introduced a considerable variety of Polynesian economic plants during their migrations from the South Pacific (Neal 1948). Ledyard's description during his 1779 hike above Kealakekua is typical. "On first leaving the town, their route lay through enclosed plantations of sweet potatoes. Now and then a patch of sugar cane was seen. Next came the open plantations, consisting chiefly of breadfruit trees, and the land began to ascend more rapidly. "(MacCaughey 1918a).

Menzies (1793) wrote that the Kau area "bore in general a very barren and rugged appearance." Later, describing his ascent of Mauna Loa, he wrote of many plantations between South Point and Kapapala and described the upper forest edge as at 6,500 feet elevation.

Captain George Vancouver remarked about extensive taro, sugar cane, sweet potato and breadfruit cultivation on Kauai, Oahu, Maui, and Hawaii during his visits from 1792 to 1794 (MacCaughey 1918b). In 1816 the Russian Captain Otto von Kotzebue remained in the Honolulu area for 2 weeks and described a walk from Honolulu to Pearl Harbor (MacCaughey 1918b, p. 425):

"The road...lay toward the west, through a beautifully cultivated valley (Nuuanu), bordered in the north by a romantic wilderness.... Sugar plantations, taro fields, and far-scattered plantations succeeded each other on our road, and we had inadvertently travelled five miles to the great village Mauna Roa (Moanalua)...."

Kosaka (1931, p. 16) quoted Macus (Macrae),<sup>1</sup> who visited the Islands in 1825 and described lands above Laupahoehoe on the Island of Hawaii as follows:

"The land six miles inland shows no sign of cultivation. It is not even pastured by livestock, being covered with long grass and short stumpy tree ferns belonging to the Cyathea tribe. We reached the outskirts of the woods between three and four in the afternoon, having on our way crossed three narrow, deep ravines, thickly covered with wood, mostly metrosideros, aleurites and a species of Rhus."

Describing the Hilo-Hamakua area, Macrae (1825, p. 57) wrote:

"The land along the sea coast from Byron's Bay [Hilo] to upwards of 40 miles to the west and about 6 miles in breadth, was free from wood excepting by the sides and bottoms of ravines. The forest that surrounds the central part of the island begins here, at a distance of 5 or 6 miles from the coast, and stretches back for a depth of 12 miles, intersected with deep valleys and large rivers of fine water.... The upper parts of the forest resemble pasture land for 7 miles further and are thinly covered with low growing shrubs and abundance of strawberries and raspberries."

Menzies (1793) noted the purposeful and frequent burning by the natives of the grassy plains in Waimea, Kauai, so that "grass grew up clear and free of stumps and was therefore better

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<sup>1</sup>I believe that Hosaka's Macus is Macrae.

adapted for thatching...." He also wrote of the cutting of huge koa trees for canoe logs and introduction of plants by natives along forest trails.

Although we are left to wonder about the nature of vegetation at specific locations, such accounts of the early explorers challenge the creditability of some later theorizing. Judd (1918, pp. 117-133) stated that "on Oahu the Leilehua plateau between the Waianae and Koolau ranges was no doubt once densely forested." But Hosaka (1931, pp. 7-8) wrote of the same area:

"It is believed that the great plateau of Wahiawa was once thickly forested but I could not find any first hand authentic statement."

And he cites Hunnewell to show that "at least by 1825 this central plain was devoid of trees."

Koebele (1900, pp. 90-97) speculated that "If we could look backward fifty or sixty years we would see the two large mountains of Maui meet by trees in the plains; Lanai and Molokai clothed with forests, ...." But Hosaka (1931, pp17-19) cites early observers to the contrary.

Hall (1904, pp. 84-102) discussed the natural conditions of rainfall, elevation, and lava flows that limited the forested area. He claimed that these "were the chief agencies restricting the forest up to about 100 years ago." Hall did not comment on the impact of use of fire, cultivation, and fuelwood cutting by early Hawaiians.

Crosby (1955, pp. 28-34) also discounted the effect of activities of the Hawaiians on the vegetation:

"Various remnants of native forest indicate that the first Polynesian settlers found trees growing on all parts of the Hawaiian Islands except a few very dry leeward areas and recent lava flows. The Polynesians cleared only limited areas for cultivation and made little use of forest products, so forest must have occupied most of the land when the islands were discovered by Captain Cook in 1778."

Yet there were probably more than 300,000 Hawaiians in the Islands in the late 1700's (Territorial Planning Board 1939, p. 23). The effect of this large agrarian force on the Hawaiian landscape was obvious to the early visitors, but not to those who came later. Neither the early visitors nor later writers have commented on the effect of pigs, rats, dogs and chickens introduced to the Islands by the Polynesian settlers, yet these animals must have had a heavy ecological impact on the native plant communities.

## Vegetation Changes After 1778

Neither the Hawaiians nor the early geographers and botanists have left a clear record of the extent of native forests in the Hawaiian Islands as they found them. They provided a much better record of the indigenous floristic composition than of its distribution and ecology (Bryan 1929). The first resident botanist in the islands, Hillebrand (1888), spent 20 years studying and classifying the flora. He describes "zones of elevation" occupied by different groups of flora. However, by 1851 when he began his studies, livestock grazing, and sandalwood cutting had already caused marked changes in the composition and extent of the forests. Other agents were also having an increasing impact on the vegetation in the Islands.

We can conclude from early descriptions that before extensive sandalwood cutting and introduction of livestock, dense forests covered much of the land above the cultivated areas and up to about 6,000 feet, especially on windward slopes. Today, they still do but apparently to a much less extent. At higher elevations, however, the forest thinned out, as described by Menzies (1793) and Macrae (1825). Many forces have worked since to decrease the forests and otherwise modify the vegetation in the Islands.



*There are still extensive areas of virgin ohia-treefern rainforest in Hawaii, but certainly much less than when Captain Cook discovered the Islands in 1778.*

## Timber Harvesting

*Sandalwood harvesting* started in 1791 and increased tremendously during the next 40 years (Thrum 1904). Hundreds of Hawaiians were engaged in cutting and hauling the wood from the mountains. This activity had lasting effect on the forest. Too late, Hawaii's first conservation law was passed in 1839, restricting cutting of sandalwood (Thrum 1904). Three-quarters of a century later, Rock (1913, p. 127) reported: "Since the large export of Sandalwood from these Islands to China, the trees have become rather scarce and only individual ones can be found scattered through the drier forests." Sandalwood trees are still scarce, but not rare.

*Cutting of forest products* has considerably modified the forests. The Hawaiian Planters' Monthly (1887, p. 437) reported:

"From every part of the islands comes the same complaint relative to the destruction of the forests. ...the charge, perhaps, ought to be laid at the door of the landowners, who allow so much wood [fuel] to be cut on their estates."

Giffard (1913, p. 42) showed concern over the cutting of fuelwood:

"The old time practice of denuding native forest areas in proximity to sugar mills, in order to secure fuel for factories, has practically ceased, but there are many sections on some of the islands where the native forests are still used as a source of fuel supplies, regardless of the disturbance and subsequent harm it does."

Korte (1961, p. 3) concluded that the demand for fuelwood by the whaling ships between 1824 and 1861 was such that "at least 10,000 acres of native forests were cut." He also cites the culture of a native fungus for food as the cause of cutting large areas of kukui forests. This was a commercial enterprise. The fungus grew well on logs felled for this purpose. Lydgate (1882, pp. 33-35) indicated that the lumber industry had an impact on the forests at an early date:

"In early times koa sawing was a regular and flourishing business.... The upland region of Hamakua, Hawaii was the center of the lumbering...and from there the lumber was mostly hauled to Waimea and thence to Kawaihae, giving to those places a degree of life and activity which they seem never likely to see again."

Korte (1961, p. 54) cites records of sawmills cutting koa prior to 1854 in East Makawao and Kula on the island of Maui. Timber cutting has continued intermittently on a small scale to the present, the greater part being in connection with land clearing for pasture use.

Harvest of tree fern products has had an impact on the rain

forest for an extended period. The plants provide useful food and fiber products (Hubbard 1952; Korte 1961; Nelson and Hornbrook 1962; Ripperton 1924; Wold, n.d.).

## Animals and Insects

*Livestock* are generally held responsible for the pronounced depletion of forests in all regions (Hall 1904; Judd 1918; Maxwell 1899). Vancouver introduced goats, cattle, and sheep into the Islands in 1792, 1793, and 1794 (MacCaughey 1918b). Cleveland landed horses in 1803 (Editor, *The Hawaiian Planters' Monthly* 1888). With a taboo laid on these animals, their numbers increased rapidly and they spread wild into the mountains. That these feral animals had a profound effect on the vegetation can not be doubted, but the magnitude can never be known.

In recounting the impact of cattle on native agriculture during those earlier days, Alexander (1894, pp. 91-100) wrote:

"In some districts agriculture was entirely ruined by the encroachments of herds of cattle, chiefly owned by foreigners.... These herds were allowed to increase without limit, until large tracts of country were completely overstocked, thousands of acres of fertile land laid waste, and the rights of native tenants literally trampled under foot. In 1851, fairly good cattle on Kauai were sold at two dollars a head, [for hides and tallow]...."

Marsden (1893, pp. 297-303) reported that ranching around Waimea, Island of Hawaii, increased greatly from 1873 to 1893 and cattle grazing caused destruction of forest on "probably 100,000 acres." John P. Parker, the founder of the famed Parker Ranch in Waimea, had begun cattle ranching activities by 1835 in this district (*Honolulu Item*, February 1930).<sup>2</sup>

Quoting from the memoirs of Wilder, Korte (1961, p. 54) gave an example of the effect of cattle ranching on the forests above Ulupalakua, Maui: "When Captain Makee in about 1852 started to grow cane at Ulupalakua a dense forest covered the side of Haleakala above the plantation ensuring sufficient moisture for crops. As years passed, cattle and other causes led to the destruction of the forest...."

Birds that were introduced to the Islands have a continuing effect on the vegetation. For example, the mynah is credited, along with other birds, as the chief agent for the spread of lantana (Perkins, 1903). Swezy (1954) cited a 1926 letter from Perkins who speculated that "When the mynah bird reached the height of their abundance in the forests, I believe the defoliation [of koa trees] by ... caterpillars really became much less frequent."

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<sup>2</sup>Information on file in the Hawaii State Archives, Honolulu.

*Insects and diseases* have no doubt played a continuing role in determining the composition and extent of forests and the vegetative cycle. The impact of these agents has been severe at times (Lyon 1909). Korte (1961, p. 2) quoted the 1875 writings of Clark, who discussed dying koa trees and stands: "... it cannot be cattle, for in many places where these dead trees stand no four-footed creature ever set its hoof."

### Fire

According to Hall (1904), fire "has done far more injury in Hawaiian forests than would be supposed in regions of so great rainfall." He told of extensive fires in the southern part of Hamakua and on Kauai and Maui. Judd (1918, pp. 117-133) emphasized that fires had a destructive effect on the forests in the past. Korte (1961) stated: "Old timers on Maui speak of a great fire that occurred in Kula in the 1880's which burnt for weeks." Walker (1888, p. 521) reported that 'Messrs. Gay and Robinson consider that in Kauai the forests where protected from cattle, are not on the decrease, except where destroyed by bush fires.' Fire continues to be a threat, and each year burns a considerable area of forest--even in wet areas. Recent examples include the 1,200 acres burned in April 1958 in the very wet Lihue-Koloa Forest Reserve on Kauai (Board of Commissioners of Agr. & Forestry 1958); and the 2,500-acre fire above Hanalei, Kauai, in June 1967.

Lava flows have cut spectacular swaths through the forests on the slopes of Mauna Loa and Hualalai, and volcanic ash and fumes have altered the vegetation over extensive areas.

### Plant Introductions

*Introduced plants* have radically altered the landscape in many parts of the Islands. They have a continuing impact on the native vegetation and floristic composition. Among the many examples is Kiawe (*Prosopis pallida*), which was introduced in 1827 (Judd 1916, pp. 330-335). The plant has spread over much of the lowlands, occupying about 150,000 acres by 1961 (Nelson and Wheeler 1963). Another example is Lantana (*Lantana camara*), about which Walker (1888, p. 521) wrote: "The invasion of the lantana bush has become a matter for very serious consideration; in Kona, Hawaii, on some parts of Maui, on this Island [Oahu] and on Kauai...." Haole koa (*Leucaena glauca*), firetree (*Myrica faya*), Christmas-berry (*Schinus terebinthifolius*), guava (*Psidium* spp.), prickly pear cactus (*Opuntia megacantha*) and other pest species have naturalized over large acreages. Some valuable timber trees have naturalized in the dry areas, including monkey-pod (*Pithecellobium saman*) and silk-oak (*Grevillea robusta*) (Nelson 1960). Others, such as Java podocarpus (*Podocarpus cupressina*) can naturalize in the rain forest (Richmond 1965).

The potential for introduced plants to effect changes in the floristic composition in the Islands is suggested by the num-



Kiawe (*Prosopis pallida*) was introduced in 1827 and now occupies about 150,000 acres of dry lowlands in the Islands. Such areas were likely treeless when Captain Cook first saw Hawaii.

ber of introductions that have been made. The Hawaii Division of Forestry alone has recorded the planting of some 1,100 different species of trees and other plants in the forests on the different islands since 1908 (Nelson 1965). Bryan (1947) made an excellent appraisal of the adaptability of many species to sites on the Island of Hawaii. Some of the tree plantings established over the years are of considerable acreage and have developed into noticeable forest stands (Nelson and Honda 1966; Honda, et al. 1967). Lyon (1918, pp. 276-280) gave this reasoning for some of the introductions: "Recognizing that our present forests are doomed and that they do not afford suitable plants with which to build up new forests there is only one line of procedure left open to us--we must introduce and establish a new flora on our watersheds."

Earlier, Hosmer (Board of Agr. & Forestry 1910) had indicated much broader purposes for introduction of tree species:

"...from the commercial standpoint much better results can be gotten from introduced species than from Hawaiian trees. The local needs in wood are for posts, ties,



*Ohia-koa forests have been opened up, and grass replaces the fern undergrowth on thousands of acres of ranch lands.*

timber and fuel. These are best supplied by introduced trees, but by no means has the last word been raised as to what introduced trees are best for local conditions."

Less conspicuous but just as aggressive as woody plants are some of the grasses and herbs that have been introduced and spread by and for livestock (Rock 1913, p. 25). Land clearing for pasture development has been the major factor changing the vegetative landscape in Hawaii over the past 100 years or more. Each year still additional areas are cleared and planted with introduced grasses.

*Sugar and pineapple plantations* have been developed partly on land originally cultivated by the Hawaiians. Additional large acreages of plantations occupy lands described by early visitors as grass-covered or treeless. Large acreages of the plantations have also been developed on once forested land, but we can only conjecture as to the actual extent. Development of other crops has expanded in recent years but the areal extent has not been great.

The combined effect of these and other agents acting on the forest and other vegetation in the Islands has been to alter greatly the boundaries and composition of plant communities over

the years. But major efforts have also been made to protect the forests. Notable are the works of foresters Hosmer and Judd. Hosmer, the first Territorial Forester, started the Forest Reserve system in the Islands in 1904. Judd, who succeeded Hosmer in 1914, continued the efforts to extend the Forest Reserve system. By 1931 more than 1 million acres were in Reserve status, and there was a concerted effort to rid these areas of all livestock and to prevent and control fires (Judd 1931, pp. 363-367). In 1966 nearly 1.2 million acres were in the Reserves (Dep. of Land & Natural Resources 1966, p. 48).

We now see a value in preserving natural areas that was not apparent earlier to those who decried the destruction of the forest because of watershed values. Some areas still can and should be selected and protected as natural areas. Foresters, botanists, and others are now working on this goal.

## Forest Types and Forest Area

Judd (1918, p. 125) stated that in 1918 "...the present area of original forest lands in Hawaii, through various agencies has been reduced until now it covers approximately only 800,000 acres...." This figure coincides with the acreage of land in "forest reserve" status at that time and is obviously not a valid estimate of area of land having a forest cover.

The Territorial Planning Board (1939) published maps and tabular data on the area of forest land on the different islands for 1900 (1,289,100 acres), 1920 (816,900 acres), and 1937 (1,027,000 acres). Obviously the latter two figures are "forest reserve" areas rather than forested areas as other records show (Board of Commissioners of Agriculture and Forestry 1920, 1936). The 1900 figure, however, was apparently an estimate of the total area of main blocks of native rain forests at that time. Forest reserves and "approximate area of forest land not in reserve" were shown on the source maps (Carter 1906). Although some of the mamani (*Sophora chrysophylla*) type was included as forest on these maps, very little of the native dryland forest was included and none of the kiawe forest type. Thus the maps and forest acreage figures fell far short of representing the true area of forested land. Crosby (1955, p. 28) conjectured that "At the time of Captain Cook's visit, about 3 million acres... in the Hawaiian Islands must have been forested. Today remnants of the native forest measure less than one million acres...."

Before 1960 there had been no maps compiled to show in any detail the different forest and other vegetation types in the Islands. As indicated earlier, Hillebrand (1888) described "zones of elevation" occupied by different groups of flora. He did not, however, develop vegetation-type maps.

Rock (1913) gave an excellent review of the flora in his six "botanical regions." He discussed the vegetation found at fairly specific locations and provided a general picture of the

areal extent of different vegetation types and flora described. In fact it is possible to relocate some of the areas he described (Mueller-Dumbois and Lamoureaux 1967). Rock did not publish maps showing distribution of vegetation.

Hosaka and Ripperton (1955, pp. 96-109) described and portrayed on maps five "vegetative zones" based on rainfall, elevation, and vegetation. They described the typical vegetation in these zones, but did not show the actual vegetation pattern in any detail. Other authors--including Hall (1904), Griffith (1903), Judd (1918), and Crosby (1955)--have described forest and other vegetation types in the Islands and their general distribution. Nelson and Wheeler (1963) provided the first and only relatively detailed information on the acreage of different defined vegetation and forest types in the Hawaiian Islands. Of their reported 2 million acres of forest land, nearly 1.1 million acres are native ohia (*Metrosideros collina*) or koa (*Acacia koa*) forest types. Their data are based on study of sample points on aerial photographs according to statistical sampling techniques. And their much-generalized portrayal of major forest types on very small scale maps was developed from study of aerial photos.

Aerial photographs have enabled the U.S. Geological Survey to provide some information about vegetation types on the standard topographic quadrangle maps the agency compiles of the Islands. In 1952, it produced the first quadrangle maps having color tints and symbols to show some of the broad vegetation types in Hawaii. These maps, which are nearly completed for all the Islands, provide a visual record of the broad vegetation pattern on the Islands.

## Hawaii Forest Type Maps

The maps described in this report are the first published record giving emphasis to the kind and extent of forest types in the Hawaiian Islands. National Park areas are excluded from coverage. The first map (quadrangle) was published in 1963, the final ones in 1965.

These forest type maps (see map appended to this report) have been compiled through interpretation of aerial photographs. The date of photography varies from 1950 through 1954. Only limited ground reconnaissance was possible. Consequently, changes in features since photography are not all shown, and interpretive error in some details must be expected. Every effort has been made to fit type boundaries to the topography of available base maps. The maps are published as blue-line prints at a scale of 1:62,500 and are suitable for coloring for pictorial representation of the types delineated and classified. They are available for purchase from the U.S. Forest Service, 630 Sansome St., San Francisco, California 94111 or from the Division of Forestry, Hawaii Department of Land and Natural Resources, P.O.Box 621, Honolulu, Hawaii 96809.

These maps were compiled primarily to provide information on the kind and extent of the forest land and timber resources in the Hawaiian Islands. On the maps, different land and vegetation types are delineated by dashed-line boundaries. In general, map scale allowed delineation to a minimum of about 40 acres. Numerical symbols within each delineated area show the broad land-use class or vegetation type and, for forest land areas, the forest type. Density of tree cover, and tree stand size class are given for commercial forest lands. The legend prepared to accompany these forest type maps shows that land areas were delineated to show the following defined classes of land and vegetation:

<u>Land Use Class</u>	<u>Map Symbol</u>
Commercial forest land	11
Productive-reserved forest land	21
Noncommercial forest land	22
Noncommercial forest pali land	23
Urban-industrial areas	30
Cultivated land	31
Grassland, forest site	32
Grassland, nonforest site	33
Nonforest pali	34
Rockland, nonpali	35
Marsh land	36
Water	37
Other, not classified	99

All lands classed as forest lands are further classified as to defined forest cover types as follows:

<u>Native or Naturalized Commercial Tree Types</u>	<u>Map Symbol</u>
Ohia	11
Koa	12
Ohia-koa	13
Silk-oak	14
Monkey-pod	16
Other	15

<u>Planted Commercial Tree Types</u>	<u>Map Symbol</u>
Eucalyptus species	21
Cedrela-Albizia	22
Other hardwood species	23
Conifers	24

<u>Noncommercial Tree and Shrub Types</u>	<u>Map symbol</u>
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Kukui	81
Ohia-koa	82
Kiawe	83
Other tree types	84
Haole koa, guava, lantana and other lowland brush types	85
Mamani and other upland brush types	86
Herbaceous types	87
Other types	88

For areas classed as commercial and productive-reserved forest lands, the maps show by additional numerical symbols, the density class (percent crown cover) of tree stands and size class of the forest stand as follows:

<u>Density of Tree Cover</u>	<u>Map Symbol</u>	<u>Stand-size Class</u>	<u>Map Symbol</u>
Dense	1	Light sawtimber	1
Semidense	2	Heavy sawtimber	2
Open	3	Poletimber	3
Nonstocked	6	Seedlings and saplings	4
		Nonstocked	6

Thus within each delineated area on the map are numerical symbols of two, four, or six digits. For example, the two-digit symbol 33 in a delineated area indicates the area is classed as grass-land not having soils and climate suitable for growing timber. An area having the symbol 31 is cultivated land or improved pasture.

The four-digit symbol 22-83 in a delineated area indicates that the area is classed as noncommercial forest land (symbol 22) and the forest type is kiawe (83).

A six-digit symbol like 11-11-23 indicates that the area delineated on the map is classed as commercial forest land (11) having a stand of ohia trees (11), the tree canopy covering 40 to 69 percent of the ground (semidense, symbol 2) and the stand is of poletimber size trees (symbol 3).

A sample map at a much reduced scale is appended to this report as *Map A*. Also, quadruplet copies of a sample section of the map--at slightly reduced scales--are appended. They are included to indicate what use can be made of the Hawaii Forest Type Maps.

On *Map B*, delineated areas of a portion of the map have been shaded or stipled in different patterns to show different land classes. This shading is based on the first or only pair of symbols in each area.

On *Map C*, the same delineated areas were examined and shaded

to show the different forest types. This shading is based on the second pair of symbols in the delineated areas. The nonforest areas are not shaded.

On *Map D*, the shading differentiates the density of tree stands only in the ohia forest types on *commercial forest land*. This shading is based on the first digit in the last pair of symbols.

*Map E* shows the same areas shaded to show the different size classes of ohia tree stands.

The best way of using these maps is through use of color shadings to highlight features of interest to the user. A variety of combinations is possible. The selection depends upon the purpose. Whatever color shading system is used, the basic classification symbols on the map can be referred to for details about a given delineated area.

The maps portray land use and vegetation cover types at a point in time. With time, land uses and vegetation change. In some areas change will be slow. In others change will be rapid and drastic, as where forest is cleared for subdivisions or pasture development. Slow or fast, minor or major, continued change is inevitable.

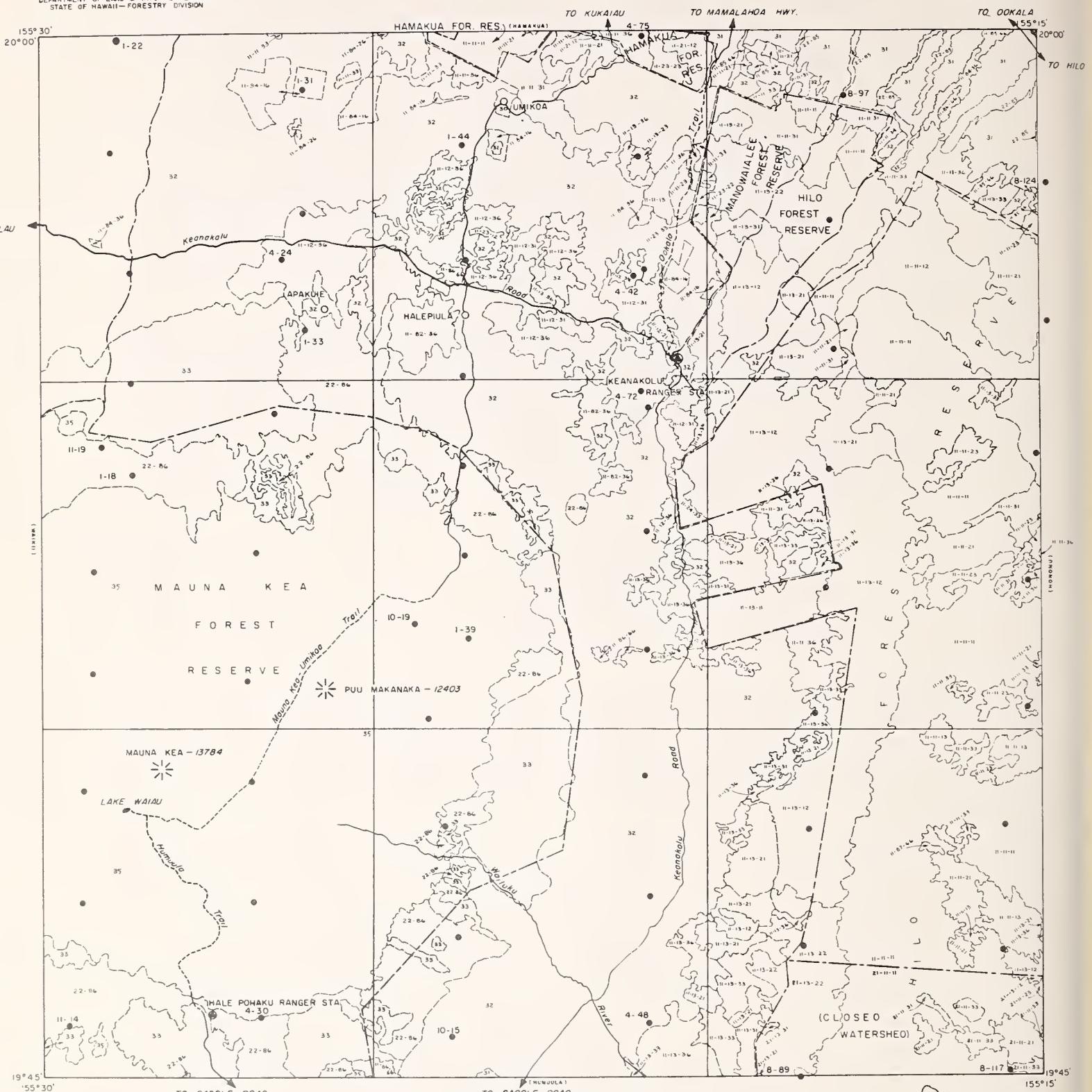
## Map A

## HAWAII FOREST TYPE-MAP

MAUNA KEA QUADRANGLE

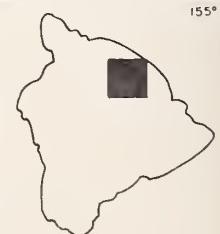
COOPERATING AGENCIES:  
 PACIFIC SOUTHWEST FOREST & RANGE EXPERIMENT STATION —  
 FOREST SERVICE—U.S. DEPT. OF AGRICULTURE  
 DEPARTMENT OF LAND & NATURAL RESOURCES —  
 STATE OF HAWAII—FORESTRY DIVISION

(LAND USE—FOREST TYPE—  
 DENSITY & SIZE CLASS—)  
 (see legend separate)



Map compilation by J. Klingensmith, 1962  
 Aerial photo interpretation by N. Handa, 1961.  
 Year of aerial photography 1954  
 (Scale 1:350000 — 1:390000)

Base map and land grid: U.S.G.S. Mauna Kea Quadrangle,  
 15 series Edition of 1945

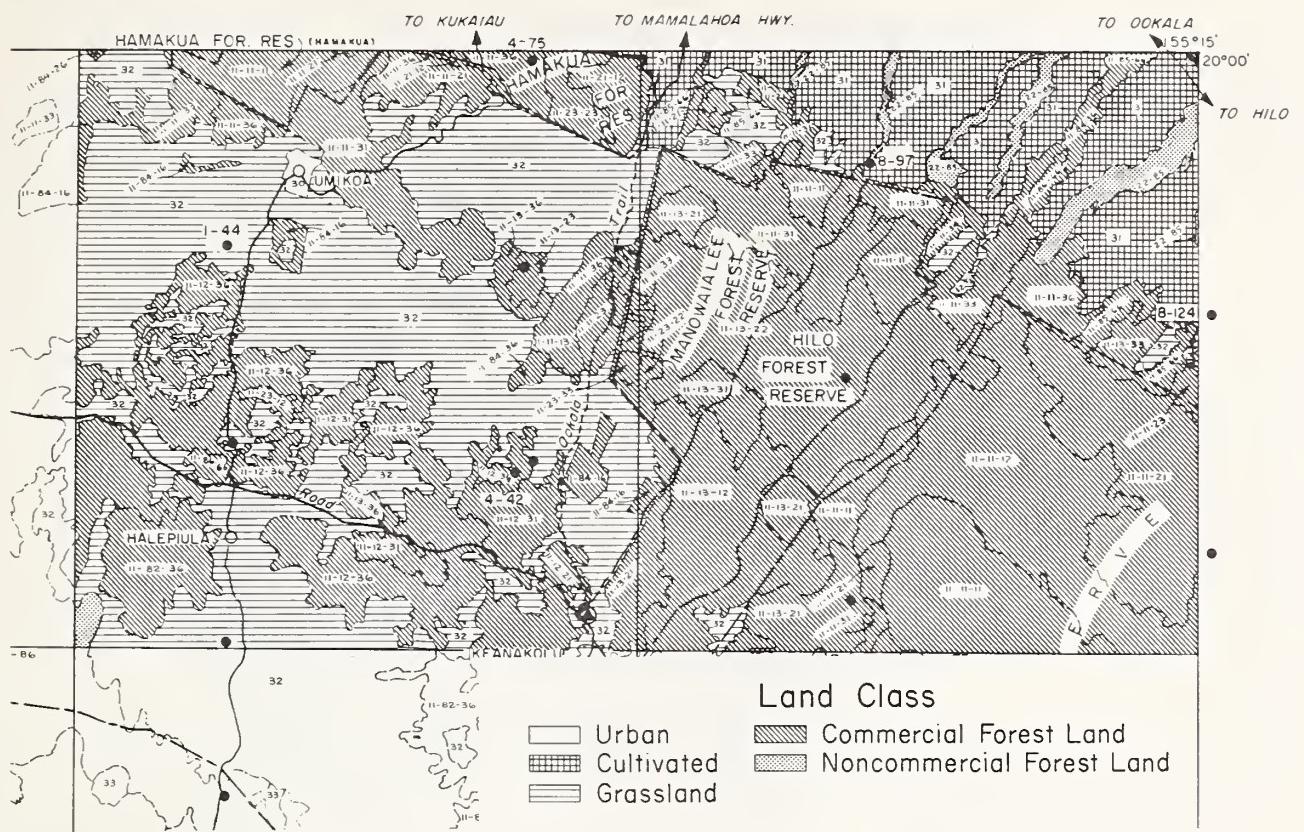


Map B

MAUNA KEA QUADRANGLE

HAWAII FOREST TYPE-MAP

(LAND USE—FOREST TYPE—  
DENSITY & SIZE CLASS—)  
(see legend separate)

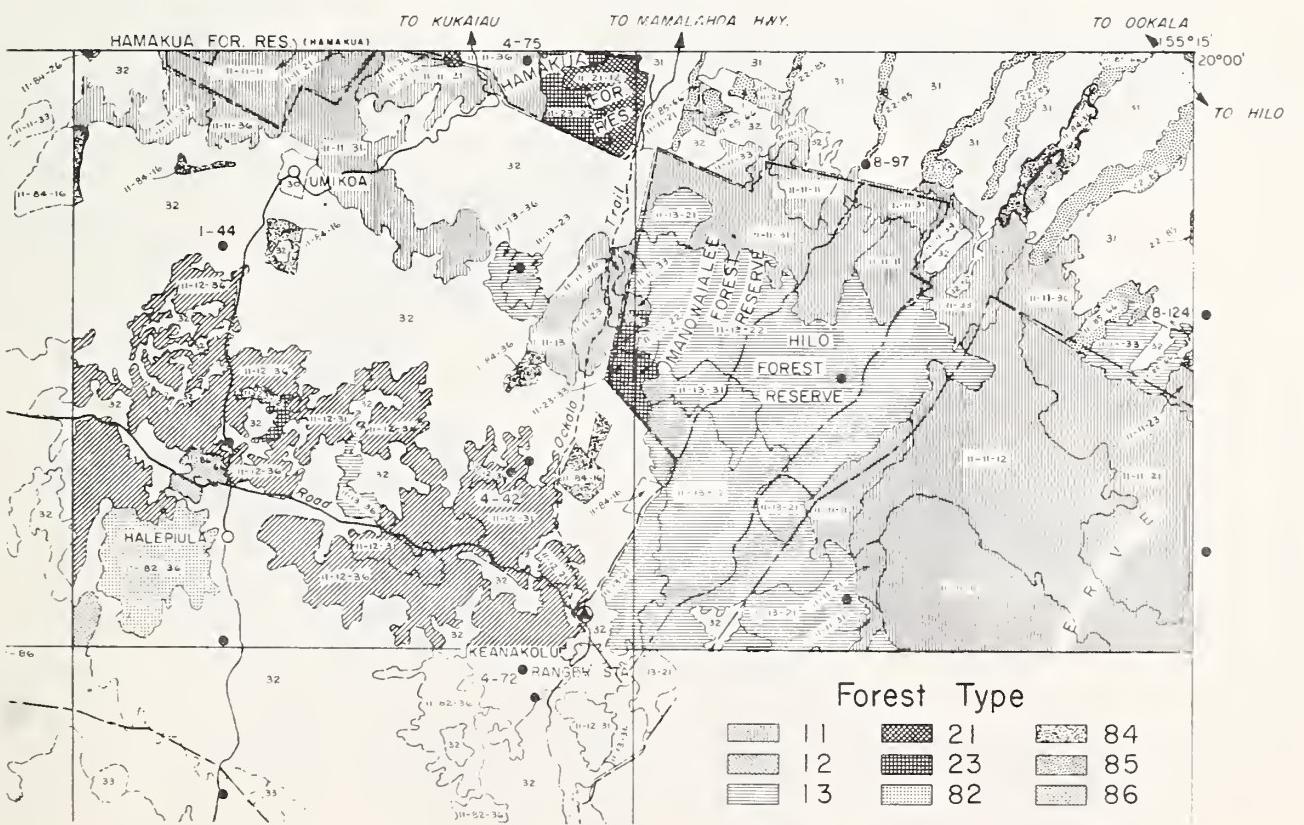


Map C

MAUNA KEA QUADRANGLE

HAWAII FOREST TYPE-MAP

(LAND USE—FOREST TYPE—  
DENSITY & SIZE CLASS—)  
(see legend separate)

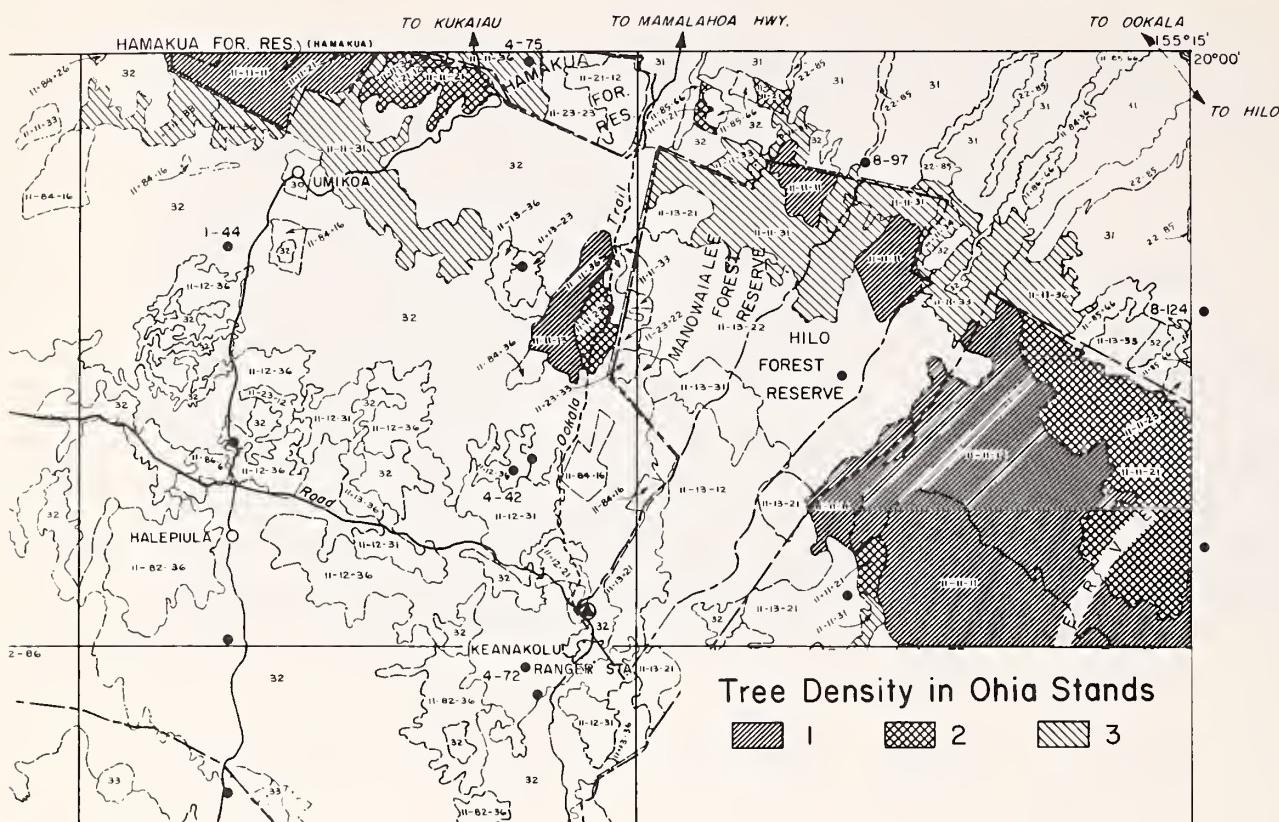


## HAWAII FOREST TYPE-MAP

Map D

MAUNA KEA QUADRANGLE

(LAND USE—FOREST TYPE—  
DENSITY & SIZE CLASS—)  
(see legend separate)

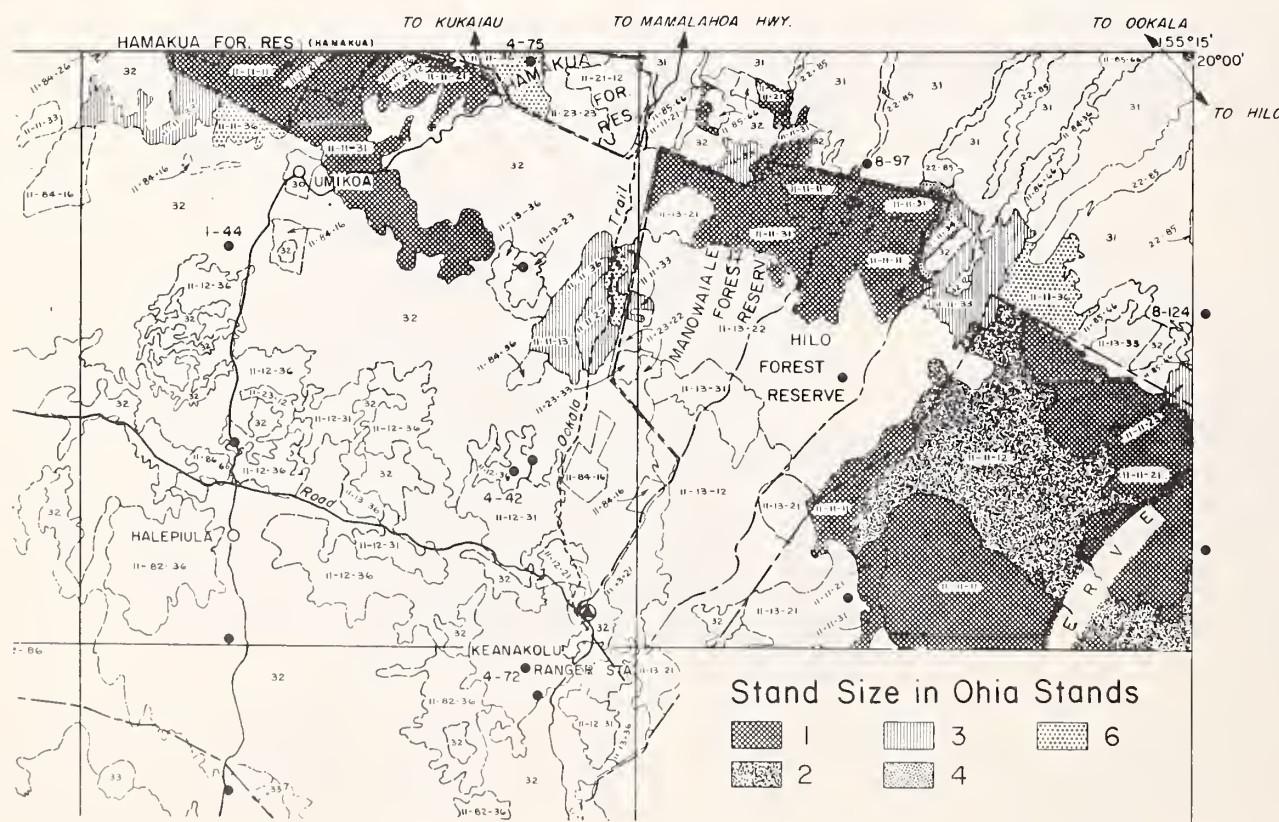


## HAWAII FOREST TYPE-MAP

Map E

MAUNA KEA QUADRANGLE

(LAND USE—FOREST TYPE—  
DENSITY & SIZE CLASS—)  
(see legend separate)



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